Management Practices to Mitigate N_2O Emissions from Agricultural Soils

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Nitrogen is Essential in Agriculture Production

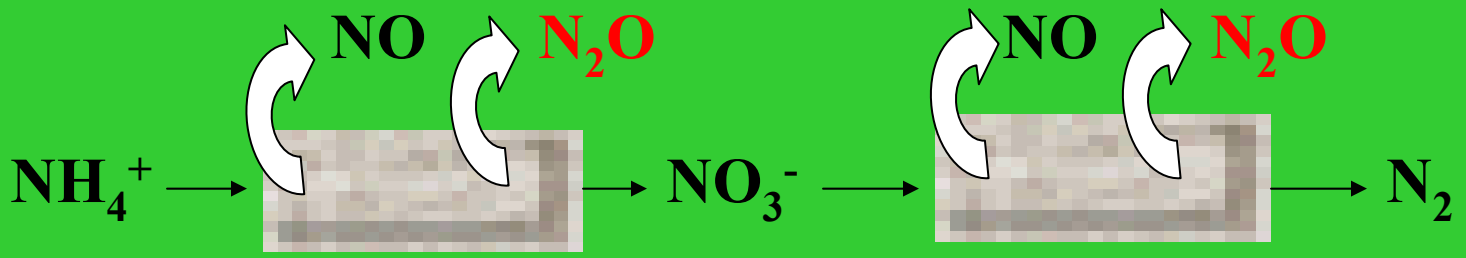
- Optimizing Crop Yields
- Optimizing Economic Returns – keeping farmers in business
- Producing High Quality, Marketable Crops with Good Nutrition

Agriculture and GHG Emissions

- Agricultural soil management accounts for about 6.3% of all GHG emission in U.S.
- Addition of reactive N to soil and emission of N_2O via soil microbiological processes (Nitrification and Denitrification) makes U.S. agriculture the largest source (62%) of total U.S. N_2O emissions.
- Management controls over N_2O emissions are related to the size of substrate N pool and the addition of N in the presence of easily decomposable C.
- High degree of uncertainty in agriculturally derived N_2O estimates.

Walter, D.T. 2005. Fertilizer nitrogen source and management impacts on greenhouse gas emissions. Proc. 21st North Central Industry and Extension Soil Fertility Conf. Nov16-17, 2005, Des Moines, IA.

Conceptual Model of N Trace Gas Production via Nitrification and Denitrification (Firestone and Davidson, 1989).



(a) Nitrification is an aerobic process where by NH_4^+ is transformed by *Nitrosomonas* spp. bacteria in soil to NO_2^- which is transformed by *Nitrobacter* spp. bacteria to NO_3^- (Follett, 2001).

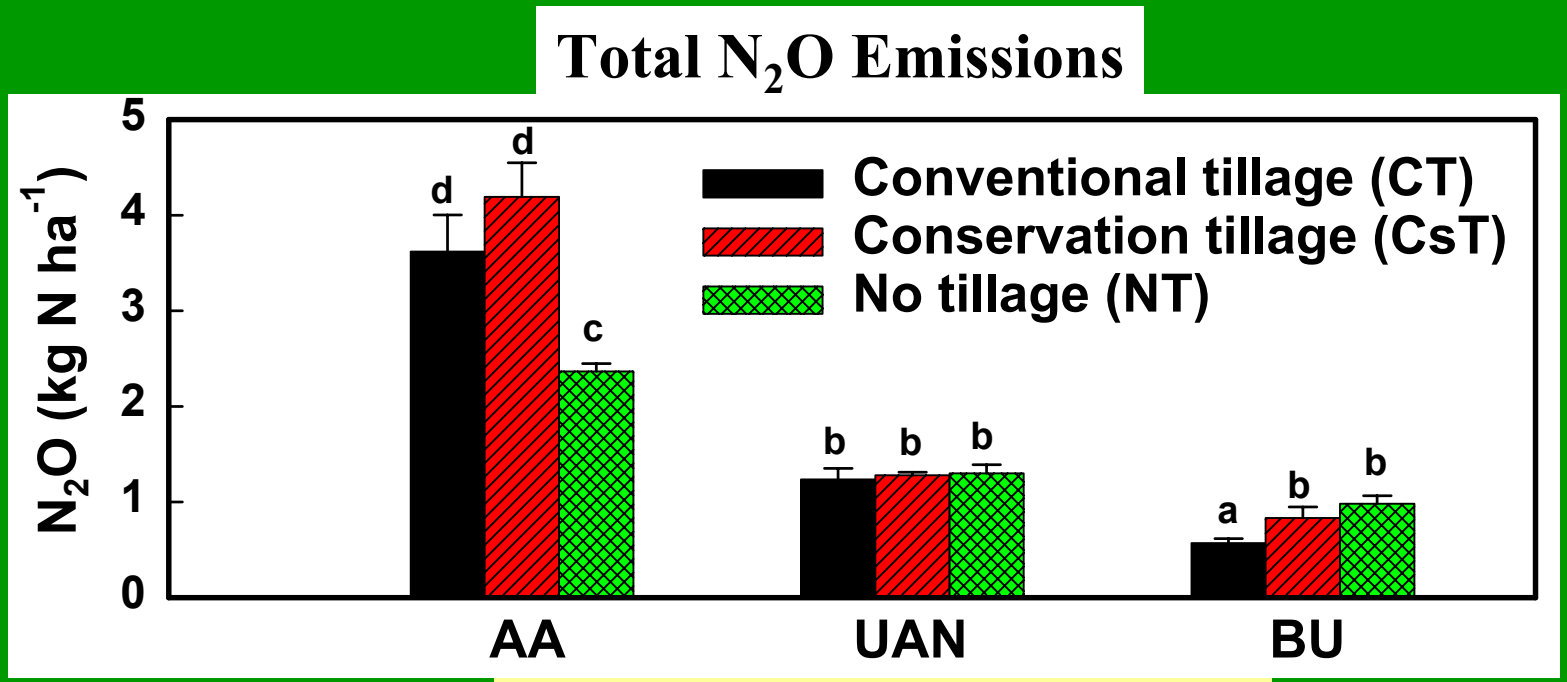
(b) Denitrification is an anaerobic bacterial process, during which NO_3^- or NO_2^- are reduced to gaseous NO, N_2O, or N_2. (Follett, 2001).

Factors Affecting N_2O Emissions from Agricultural Systems:

- Soil temperature, water, and texture
- Anaerobic soil conditions (reduced oxygen supply)
- Microbial and fungal populations and type
- Legumes in crop rotation
- Crop residue type and amount (C:N ratio)
- Type of N fertilizer applied
- Fertilizer placement in soil
- Tillage system
- Year to year variations in climate – Temp. & Precip.
- Irrigation system – Furrow, Sprinkler, Drip

- Because of the above factors, N_2O emissions from soil are highly variable and unpredictable.

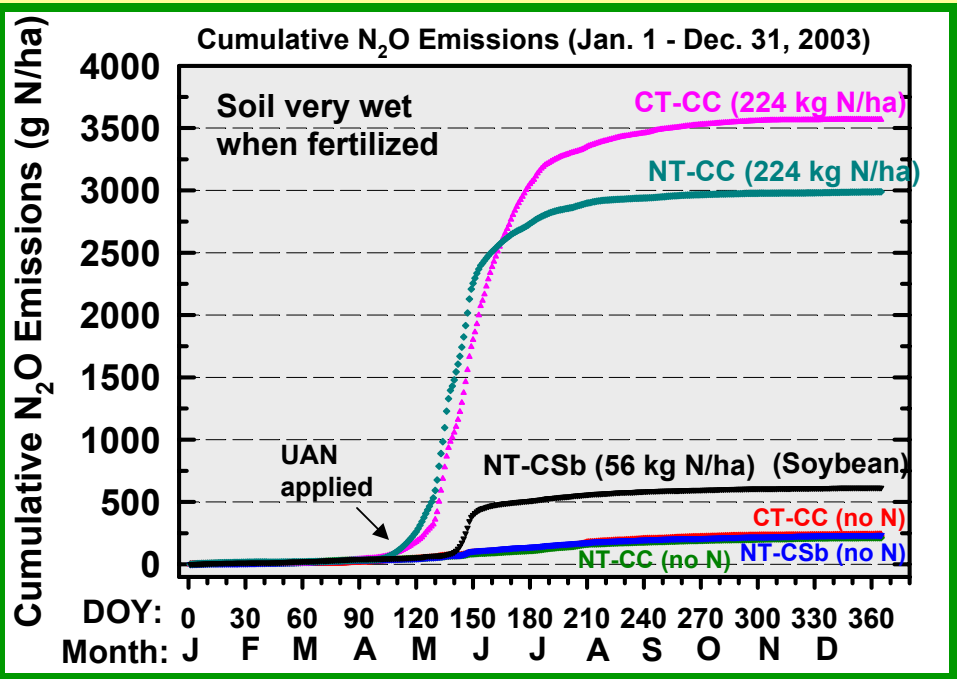
Fertilizer N Source Affects N_2O Emissions

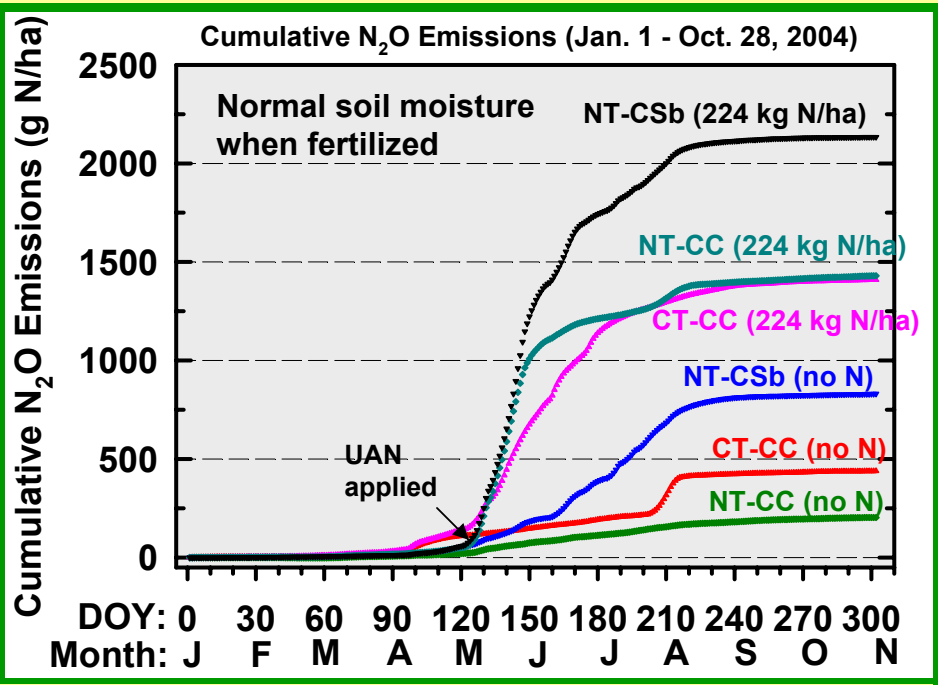


(Venterea et al. 2005. JEQ. 34:1467)

Walters (2005) also suggested that there is little difference in N_2O emission between fertilizer N sources, except for anhydrous ammonia (AA) which generally results in ~4 to 5 fold greater N_2O emissions than other N sources.

Irrigated Cropping System Effects on N_2O Emissions in Colorado





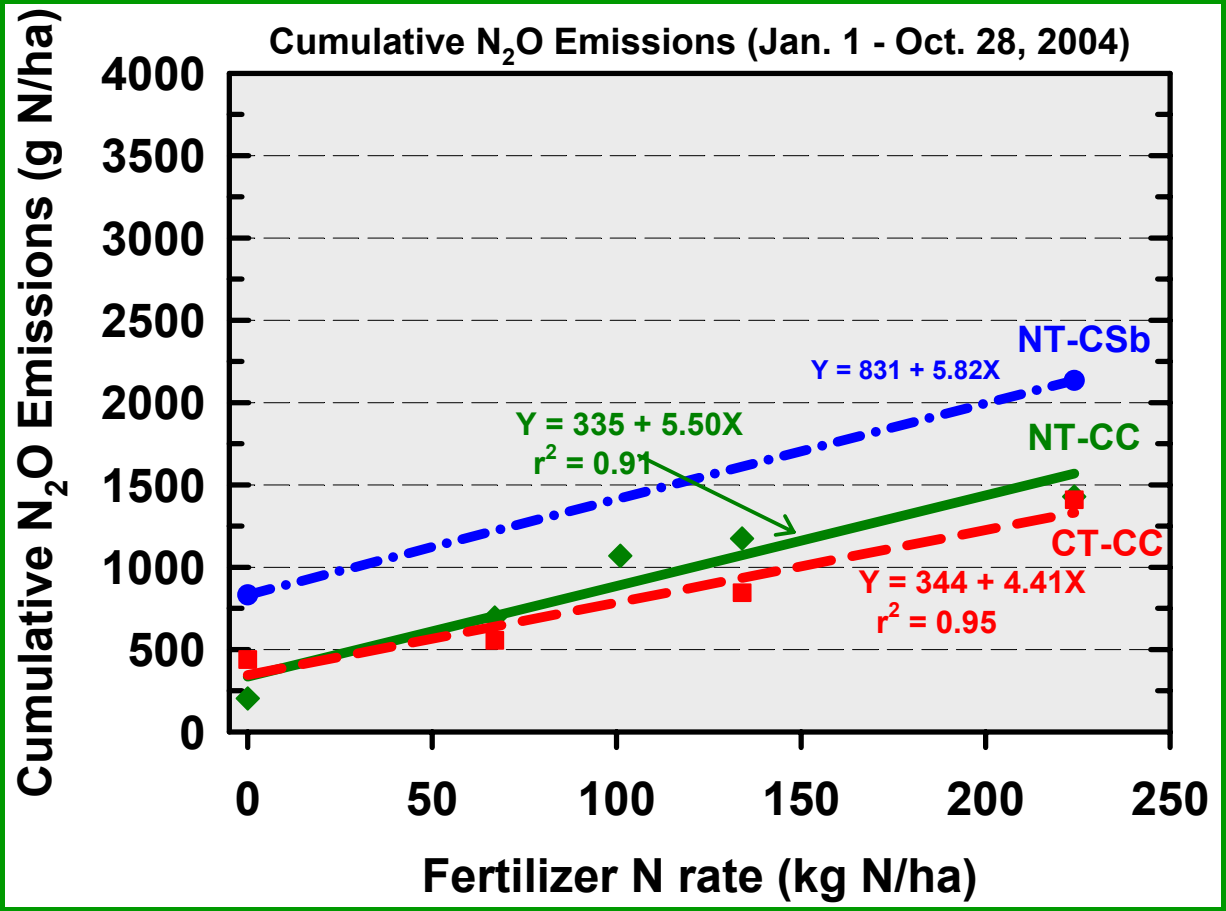
CC = continuous corn; CSb = Corn-Soybean; NT = no-till; CT = Conv. Tillage

(adapted from Mosier et al., 2006, JEQ)

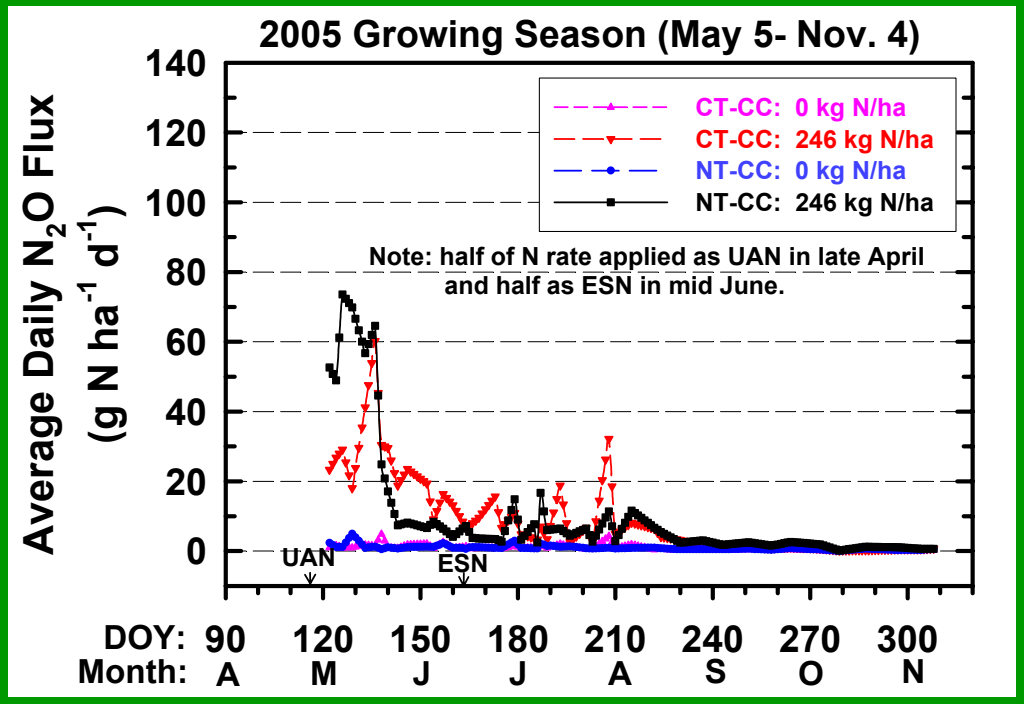
Walters (2005) also showed higher N_2O emissions during the corn year following soybean in a corn-soybean rotation in Nebraska. Missouri research reported soybean had the highest N_2O emissions when compared to non N_2-fixing crops (Nkongolo, 2007).

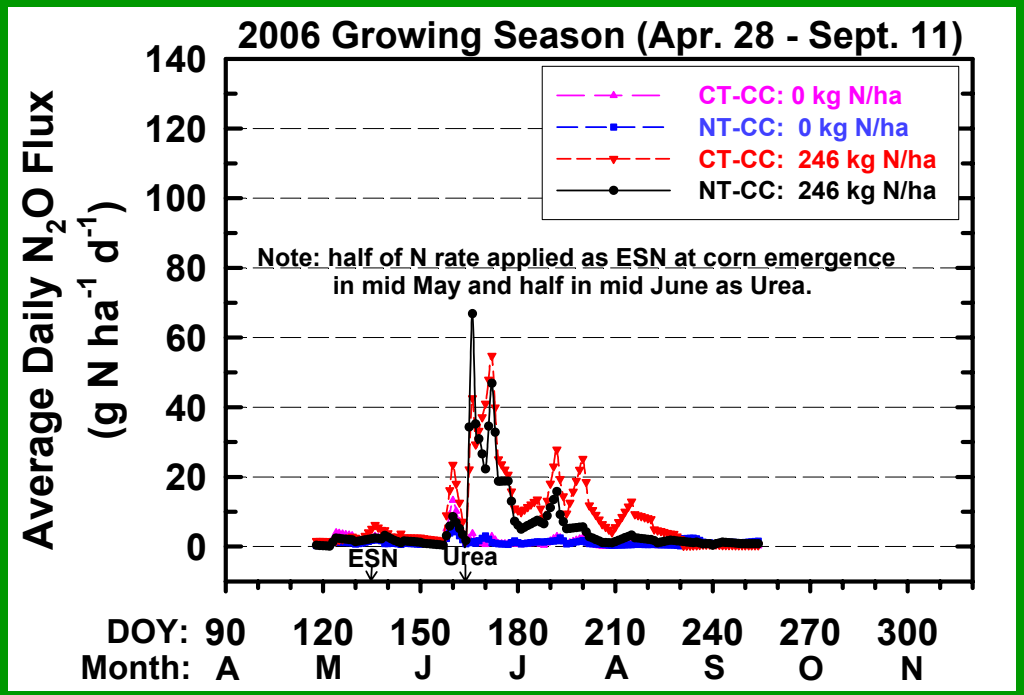
In California, Rolston et al. (2007) reported low N_2O emissions prior to N fertilization and irrigation, with slightly higher N_2O emissions from minimum till system compared to standard tillage practices.

N_2O emissions from N fertilizer application increased linearly with increasing N rate each year from 2002 - 2006, but total emissions varied with year in irrigated cropping systems near Fort Collins, CO (Mosier et al., 2006; Halvorson & Del Grosso, 2007).



Estimated N_2O emissions, as a percent of N fertilizer applied, averaged 0.66, 0.60, and 0.63 % for the CT-CC, NT-CC, and NT-CSb rotations, respectively, from 2002 – 2006, varying from 0.3% to 1.53% depending on year. This is below the IPCC factor of 1% used in calculating the National GHG Inventories (IPCC, 2006).





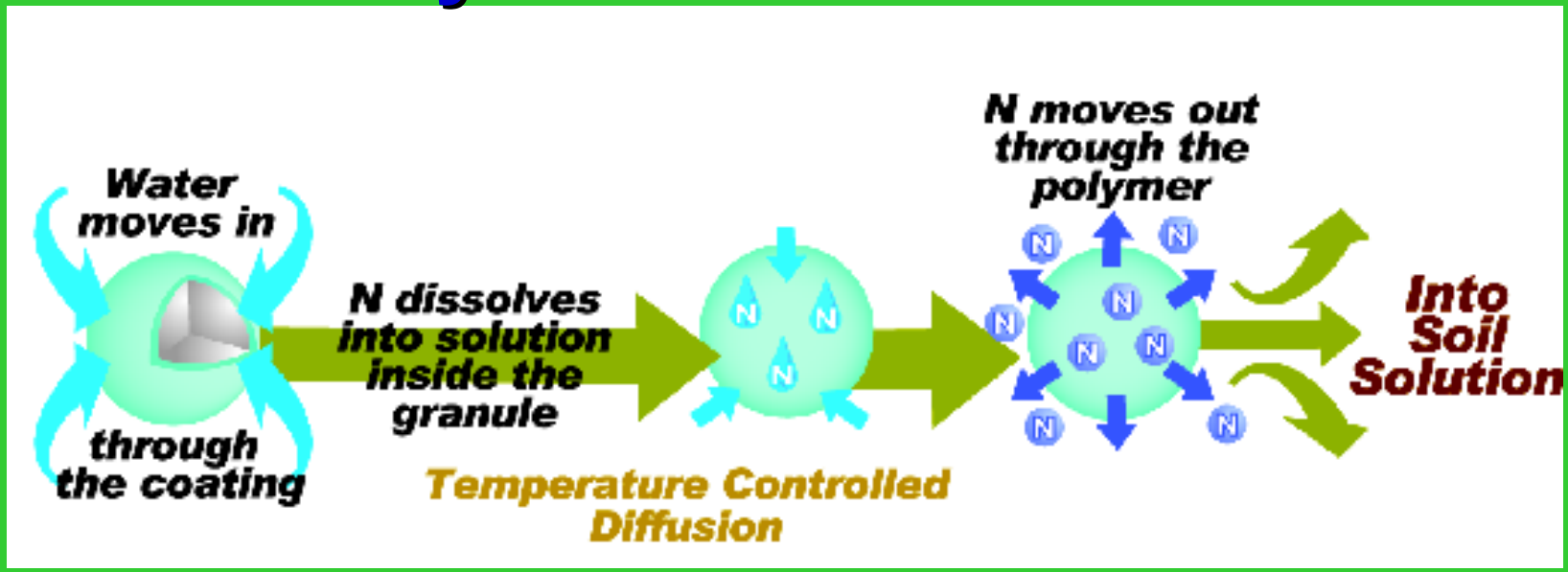
Polymer-Coated Urea

Application of polymer-coated urea (ESN®) resulted in lower N_2O emissions than with UAN or Urea (Halvorson and Del Grosso, 2007).

Blaylock et al. (2004) reported reduced N_2O emissions with ESN® compared to other N fertilizer sources and improved N-use efficiency by the crop.

Research in Nebraska under irrigated crop production also found lower N_2O emissions when ESN® was used (Personal communications with Dan Walters, UNL, (2-6-07))

Polymer coated urea



- N release controlled by diffusion
- Major factors affecting release
  - coating thickness
  - temperature
  - moisture

Figure courtesy of Dr. Mike Stewart, IPNI

Conclusions from Colorado Studies:

- Increased N_2O emissions from N fertilization (UAN or Urea) occurs during the first 30-40 days following fertilization, with N_2O fluxes declining to near background levels thereafter.
- No residual effects of N fertilization on N_2O emissions late in the growing season or during the non-crop period.
- Total growing season N_2O emissions vary with year, but are proportional to the amount of N applied.
- Tillage system does not appear to have much affect on N_2O emissions, but inclusion of soybean or dry bean in the rotation increases N_2O emissions.
- A polymer-coated urea (ESN®) shows potential for reducing N_2O emissions in irrigated systems, but more research is needed to verify this observation.

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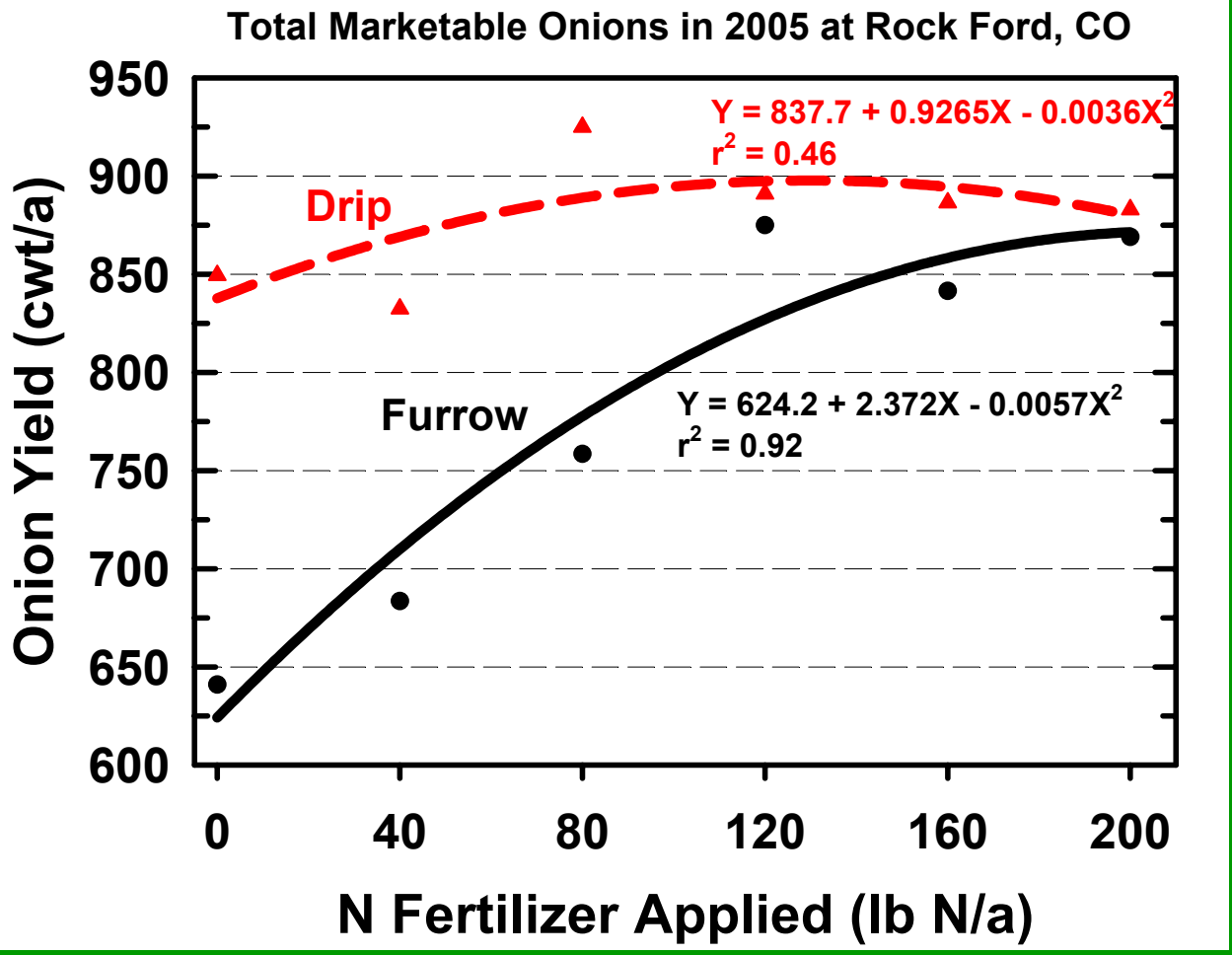
Other Management Options

- **Apply N through drip or sprinkler irrigation systems throughout growing season.**

- **Convert to reduced- and no-till production systems (reduce fossil fuel consumption, sequester SOC), offset N_2O emissions.**

Irrigation Method vs N Needs of Onion



Halvorson et al., 2006. GPSF Conf.

Examples:

Improved N use-efficiency by onion with drip irrigation in Colorado.

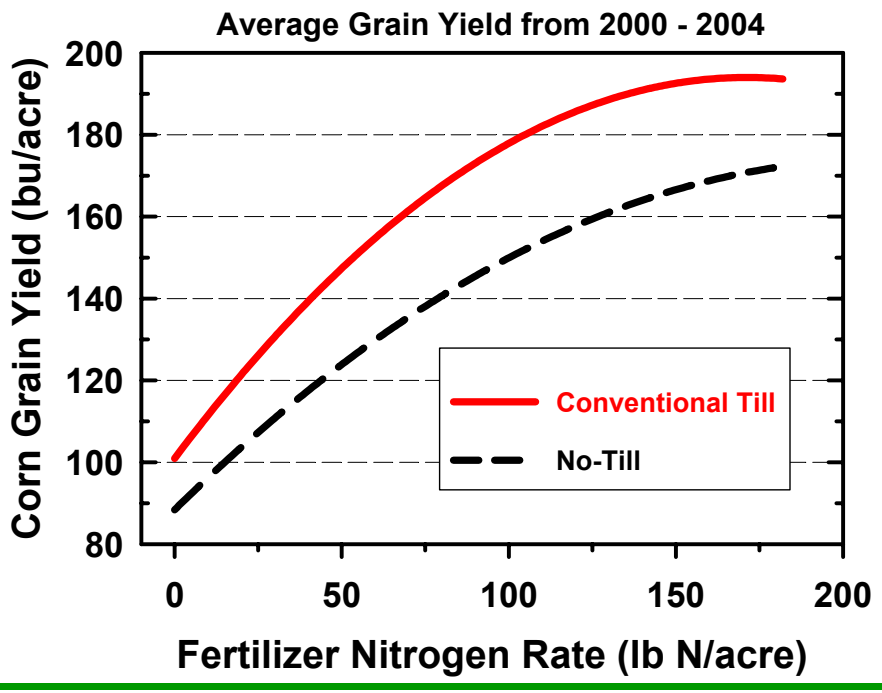
Drip vs furrow irrigation work with tomatoes in California shows less N_2O emissions with drip irrigation (Kallenbach et al., 2007).

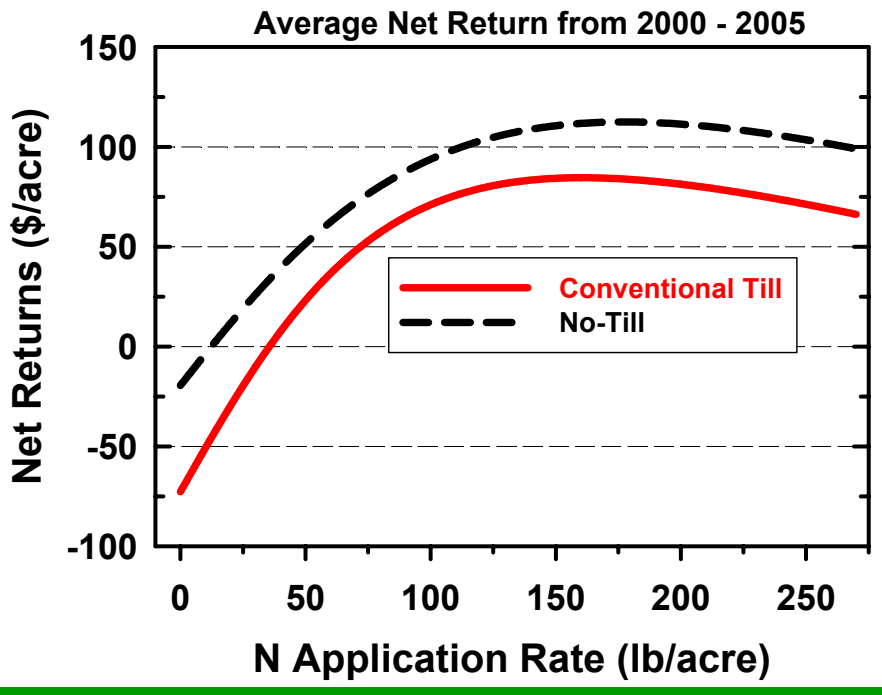
Fertigation of corn with sprinkler irrig. system in Nebraska did not increase N_2O emissions (Ginting & Eghball, 2005)

Converting to Conservation Tillage Systems to Offset N_2O Emissions

- **Conventional intensive tillage practices results in the loss of soil organic carbon (SOC) and release of CO_2 to the air.**
- **Reduced-Till and No-Till Farming Systems can reduce CO_2 emissions and sequester SOC.**
- **Reduced- and No-Till systems can reduce soil erosion, fossil fuel consumption, and production costs.**

No-till production: leaves crop residues on the surface – reducing soil erosion and enhancing soil organic C and N sequestration





Continuous Corn Production:

No-Till (NT):

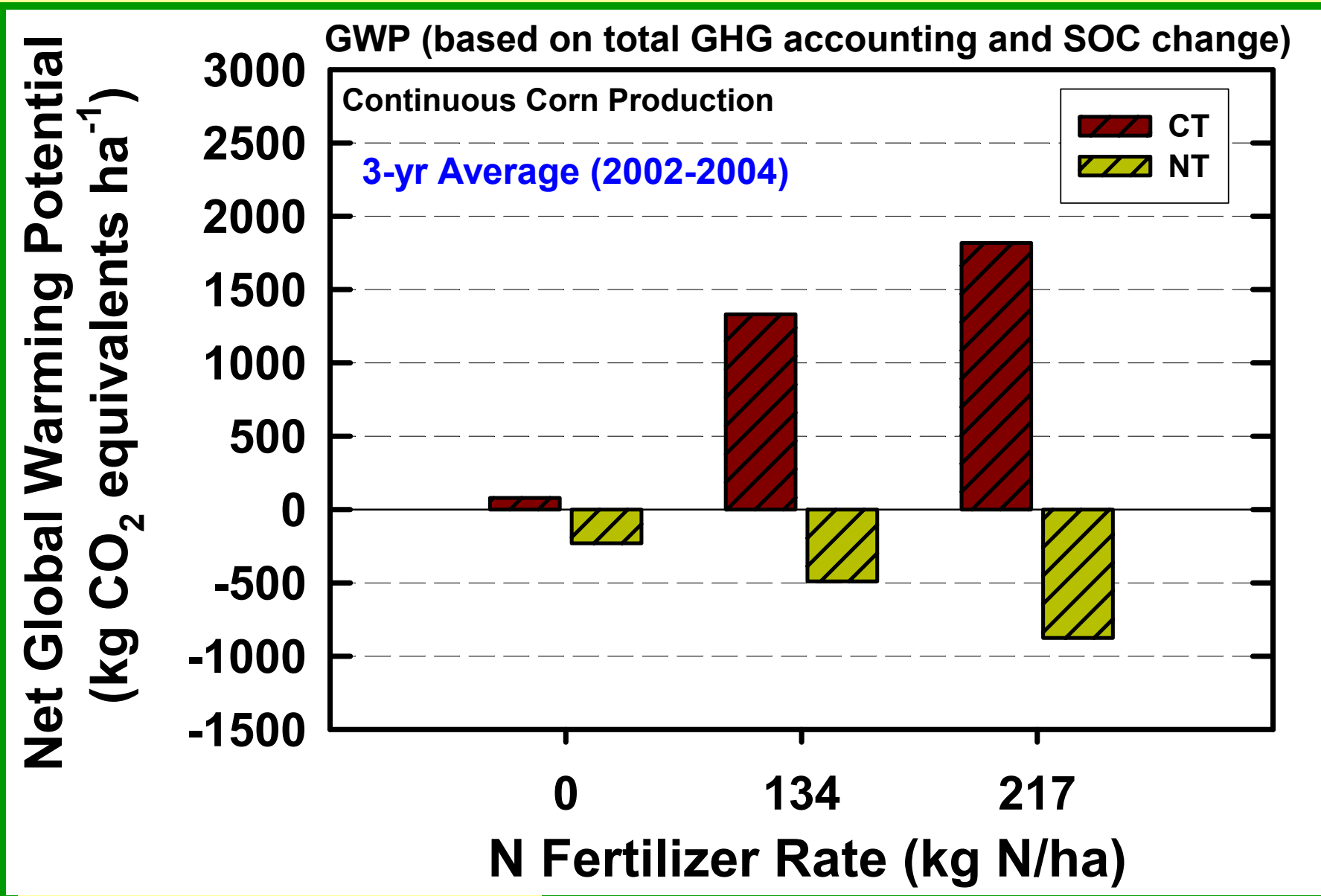
Plant
Spray for pest control
Harvest

Conventional Till (CT):

Shred corn stalks
Disk
Moldboard plow
Disk
Roller Harrow
Landplane (2 operations)
Plant
Spray for pest control
Harvest

Adapted from Halvorson et al., 2005

Global Warming Potential Within NT and CT Irrigated Continuous Corn Systems Near Fort Collins, CO



Adapted from Mosier et al., 2006 JEQ

Managing N_2O Emissions

- N_2O emissions are proportional to the rate of N fertilizer applied (reduce N rate – reduce N_2O emissions)
- Soil test to determine residual soil N levels before applying N fertilizer
- Apply only BMP N dosages to crops that insure economic optimum return
- Source of N fertilizer applied
  - Anhydrous Ammonia (~4 to 5 fold higher N_2O emissions than other N sources)
  - Change from AA to other N sources: polymer-coated fertilizers, fertilizers treated with urease and nitrification inhibitors, controlled release N fertilizers.

Managing N_2O Emissions

- Apply N in small quantities during the growing season through drip or sprinkler irrigation systems.
- Avoid very wet soil conditions when applying N fertilizer.
- Reduce soil area fertilized – put fertilizer in bands near plant row.
- Fertilizer N placement – surface, shallow, or deep in soil (Liu et al., 2005; Drury et al. 2006; Venterea, 2007)
- Convert to NT system to offset N_2O emissions by sequestering more SOC, reducing fossil fuel consumption, and reducing soil erosion.

Thanks for Listening!!!

Questions??